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THE USE OF MINERALS AS RADIO-DETECTORS

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Minerals play an important rôle in wireless telegraphy and telephony. The most common and least expensive type of receiving outfit makes use of the so-called crystal-detector, which takes advantage of the electrical properties of certain crystalline substances. The object of this note is briefly to summarize the present state of our knowledge concerning crystal-detectors, and to call attention to the possibilities of improvement and the desirability of further research in this field.

The action of a detector may be explained as follows: The alternating currents induced by radio waves are of such high frequency that even if a telephone were produced whose diaphragm could vibrate in time with them, the sound resulting from this vibration would be so shrill as to be beyond the range of the human ear. In order that they may be made audible, the waves must either (1) be broken up into like groups or trains which follow one another at an audible frequency (wireless telegraphy), or (2) so "modulated" that their amplitude varies in time with an audible vibration such as speech or music (wireless telephony). In either case they remain high frequency electromagnetic waves. In the receiving apparatus, the high frequency—or "radio-frequency"—electromotive force is impressed on a circuit whose function is to distort the alternating current wave in such a way that more current flows in one direction than in the other. This distorted wave may now be thought of as the sum of a radio frequency alternating current and a direct current, of which only the direct current is capable of actuating the telephone receiver. The ideal detector would allow current to pass freely, but in only one direction. A detector is, then, merely an electrical rectifier, and altho in actual practice the rectifying action is far from complete, yet a certain amount of direct current

is produced; moreover, it is a *pulsating* direct current, and the final effect in the telephone circuit is an alternating current of comparatively low ("audio-") frequency. Therefore, as the amplitude of the original radio wave changes, the diaphragm vibrates and reproduces—more or less faithfully—the changes impress on the radio wave at its source.

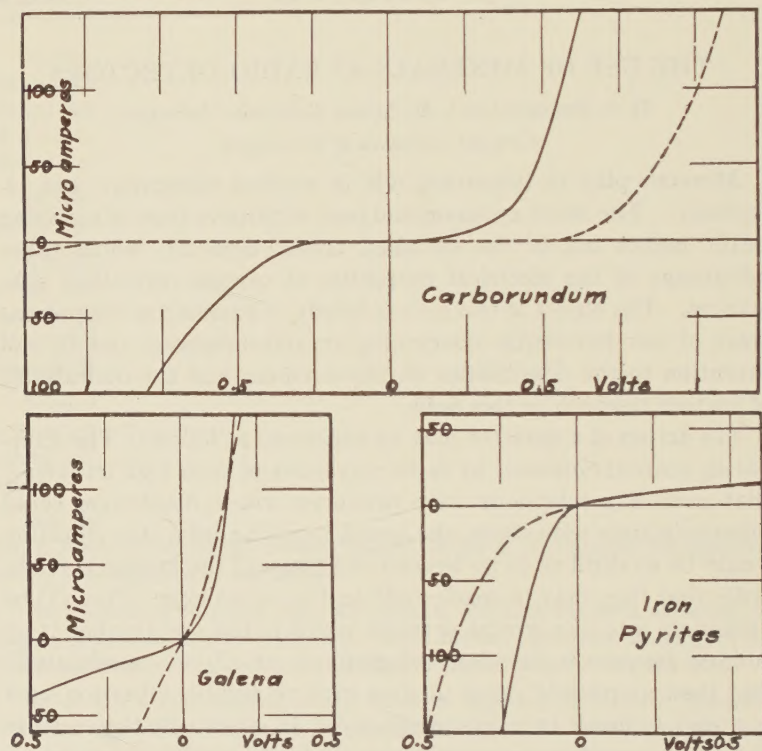


FIGURE I

CHARACTERISTIC CURVES FOR TYPICAL CRYSTAL-DETECTORS

Each of these crystals was mounted in a block of fusible metal. In the case of the carborundum crystal, a flat steel spring, pressing against one of the corners of the crystal, formed the second contact. In the case of the other two, contact was made with a pointed wire of a copper-nickel alloy. The current, in millionths of an ampere, is plotted against the potential difference in volts between the fusible metal base and the spring or wire contact. The solid curve in each case is the characteristic of the more sensitive detector.

The crystal-detector consists essentially of a small area of contact between two suitable conductors, at least one of which is a

crystal. It operates by virtue of the fact that the current flowing thru such a contact is not proportional to the electromotive force driving it. This property is illustrated by the curves in figure 1. The efficiency of the detector depends to a great extent on the circuit with which it is used, but in general the efficiency increases with the sharpness of curvature of the characteristic curve and with steepness of the vertical branch.¹

The more important substances which have been used as detectors are listed in Table 1. Of these substances, all are minerals except silicon and carborundum. The materials marked with an asterisk are known to have been used only in contact with another mineral—usually zincite; the others are commonly operated in contact with a metal.

TABLE 1. THE MORE COMMON MATERIALS USED FOR CRYSTAL DETECTORS

Name	Composition	Symmetry	Cleavage
Galena	PbS	Isometric	(100), perfect; (111), less often
Pyrite	FeS ₂	Isometric pyritohedral	(100) and (111), indistinct
Carborundum . . .	SiC	Rhombohedral	None
Zincite	ZnO	Hexagonal-hemimorphic	(0001), perfect; (10 $\bar{1}$ 0), sometimes distinct
Octahedrite . . .	TiO ₂	Tetragonal	(001) (111), perfect
Brookite	TiO ₂	Orthorhombic	(110), indistinct; (001), still more so
Bornite	Cu ₅ FeS ₄	Isometric	(111), traces
Chalcopyrite . .	CuFeS ₂	Tetragonal-sphenoidal	(201), sometimes distinct; (001), indistinct
Molybdenite . . .	MoS ₂	Hexagonal	(0001), eminent
Argentite	Ag ₂ S	Isometric	(110), (110), traces
Covellite*	CuS	Hexagonal	(0001)
Niccolite*	NiAs	Hexagonal	
Enargite*	Cu ₃ AsS ₄	Orthorhombic	(110), perfect; (100), (010) distinct; (001), indistinct
Silicon	Si	Isometric	

¹ The combination of crystal detector and telephone is essentially a device for the conversion of energy from one form to another, and as such the efficiency of conversion should be high. Of the total electrical energy in the circuit, a small portion is given to the telephone in the form of a pulsating direct current to be converted into sound. A large part of the energy associated with this direct current, as well as all of the energy not directly associated with it, is wasted in the form of heat. It is therefore desirable, first, that the crystal contact oppose a very high resistance to the flow of current in one direction, in order to increase the ratio of direct to total current; and second, that it oppose a reasonably low resistance to the

From a study of this table it may be seen that all of the substances are of comparatively simple composition; only 3 of the 14 materials contain as many as 3 elements. Consequently, crystal systems of high symmetry predominate: 10 of the substances belong either to the isometric or to the hexagonal system, while the monoclinic and triclinic systems are not represented at all. As regards cleavage, no regularities are apparent. Some good detectors, such as galena and zincite, show well-developed cleavage, while others, pyrite for example, cleave only indistinctly.

The mechanism of conduction in a crystal rectifier and the reasons for its unilateral conductivity are not well understood. Numerous theories have been advanced to explain the operation of crystal-detectors; for example, the direct current yielded by a crystal has been ascribed to thermo-electromotive forces at the contact or junction. Without attempting to review the subject completely, or to discuss the merits of the various theories, we shall merely note what seems to us the simplest type of explanation.

It is common knowledge that a fragment of material such as galena possesses the rectifying property only at certain spots on the surface; moreover, these "sensitive spots" are usually not on smooth parts of the cleavage-surfaces, but seem to show a preference for places where the surface is irregular. It is not unlikely that at these sensitive spots there is indistinct octahedral cleavage and that the sensitive spots are merely small surfaces parallel to the octahedral faces (111). Now, the (111) planes of galena contain either all lead or all sulfur atoms, and a boundary layer containing only one kind of atom might be expected to exhibit a strong unbalanced electrostatic field due to the electrons of the oriented atoms. The (111) planes, then, in contact with a conductor, e.g. a metallic point, would, according to this view, yield an unsymmetrical conductivity curve as result of the unbalanced electrostatic field at the contact, the adjacent electrons playing a rôle analogous (altho perhaps not similar) to that of the electrons in a vacuum-tube detector.²

flow of current in the other direction, in order to increase the total current. The characteristic of such a crystal, if plotted in the figure, would consist of two lines nearly parallel to the two axes and connected by a very sharp curve. The first of the two desiderata is found in carborundum and the second in most of the other common detectors; but a substance combining the two is yet to be discovered.

² There is also a striking similarity between the current-voltage characteristic of the vacuum tube and that of the crystal detector.

Granting the correctness of this view, we might expect that any crystalline material which is a conductor of electricity would show a rectifying action at any surface (cleavage or crystal face) at which there exists a layer of only one kind of atom. This last condition is readily attained only in crystals of simple composition. Pyrite, another favorite detector, shows cubic and also octahedral cleavage, both indistinct. The (100) planes as well as the (111) planes contain either all iron or all sulfur atoms, and with pyrite, therefore, presumably any true cleavage surface would, if of a size comparable with that of the contact point, be a sensitive spot.

For other crystals, such as carborundum, the relation is not so simple. This substance seems to function best when a "point" of the hexagonal plate is pressed against a hard metal surface, the other electrical connection being made as usual by embedding a considerable part of the crystal in metal. The "point" is really a small edge formed by the intersection of two prism or of two rhombohedral faces. The crystal structure of carborundum is not well known, but if it should turn out that the sensitive edges are formed from one kind of atom, the action of this type of detector would also be explainable by the hypothesis here proposed. It must be admitted that little really conclusive evidence can be adduced in favor of this view, but at least there are no facts which controvert it, and it is offered as a simple and reasonable working hypothesis. Further research on the rectifying properties of properly identified crystal surfaces is obviously needed.

In comparison with the vacuum-tube detector, the crystal-detector is simpler, more compact and cheaper. In its present form it is considerably less sensitive than the vacuum-tube and can not be used as an "amplifier." It has, however, a considerable field of usefulness which might be greatly broadened if its sensitivity could be increased.

A list of the more important papers dealing with crystal detectors is appended.

Crystal rectifiers for alternating currents and electric oscillators. G. W. Pierce. *Phys. Rev.*, **25**, 31, 1907.

Contact rectifiers of alternating currents. L. W. Austin. *Bull. Bur. Standards*, **5**, 133, 1908.

Crystal rectifiers. G. W. Pierce. *Phys. Rev.*, **28**, 153; **29**, 478, 1909.

Crystal and solid contact rectifiers. A. E. Flowers. *Phys. Rev.*, **29**, 445, 1909.

Stratified structure of tin ores and crystal detector action. T. Liebisch. *Sitz. Ber. Akad. Wiss. Berlin*, **18**, 414, 1911.

Unilateral conductivity of minerals in contact. M. Kimura. *Mem. Coll. Sci. and Eng. Kyoto*, 2.4., 63, 83, 1910.

Unidirectional conductivity of crystal detectors. G. Leimbach. *Physik. Z.*, 12, 228, 1911.

Stratification and capacity of carborundum. Electrical properties of crystals. G. W. Pierce and R. D. Evans. *Proc. Am. Acad.*, 47, 793, 1912.

Conduction of electricity at contacts of dissimilar solids. R. H. Goddard. *Phys. Rev.*, 34, 423, 1912; *Electrician*, 69, 778, 1912.

Characteristic curves and sensitiveness tests of crystals and other detectors. P. R. Coursey. *Proc. Phys. Soc.*, 26, 97, 1914.

Characteristics of contact rectification with a silicon-carbon contact. R. C. Hartsough. *Phys. Rev.*, 4, 306, 1914.

Variation of resistance with voltage at a rectifying contact of two solid conductors, with application to the electric wave detector. D. Owen. *Proc. Phys. Soc.*, 28, 173, 1916.

Law of response of the silicon detector. L. S. McDowell and F. G. Wick. *Phys. Rev.*, 8, 133, 1916.

The rectifying property of silicon and its place in the thermoelectric series. F. Fischer and Baerwind. *Physik. Z.*, 17, 373, 1916.

Influence of time element on resistance of a rectifying contact. *Proc. Phys. Soc.*, 24, 33, 1916.

The mode of operation of crystal detectors. B. Theime. *Physik. Z.*, 17, 615, 1916.

Electrolytic phenomena of the molybdenite detector. M. J. Huizinga. *Proc. Acad. Sci. Amsterdam*, 19, 512, 1917.

Unidirectional resistance of contact detectors. M. J. Huizinga. *Proc. Acad. Sci. Amsterdam*, 21.9, 1248, 1919.

Permanent contact crystal detectors. L. S. McDowell. *Phys. Rev.*, 13, 228, 1919.

Reproduction of speech by galena. P. Collet. *Compt. Rend.*, 170, 1378, 1920.

Rectification by galena. P. Collet. *Compt. Rend.*, 170, 1489, 1920.

Dilation at the point of contact of two solids, due to the Joule-effect. J. Fallou. *Compt. Rend.*, 170, 1308, 1920.

Reaction time of contact detectors. R. Ettenreich. *Ber. Akad. Wiss. Wien.*, 128, 1169, 1919.

Unipolar conductivity of crystals. F. Streinz and A. Wesely. *Physik. Z.*, 21, 42, 1920.

A beat method to test the reaction time of contact detectors. R. Ettenreich. *Physik. Z.*, 21, 208, 1920.

The cymoscopic detector properties of galena. P. Collet. *Ann. Phys.*, 15, 265, 1921.

The action of the silicon carbide detector. F. Luchsinger. *Physik. Z.*, 22, 487, 1921.

Carborundum and its rectification effect. H. M. Dowsett. *Radio Review*, 2, 580, 1921.

Detecting properties of galena. P. Collet. *Ann. Phys.*, 15, 265, 1921.

THE ANTIMONY ORES OF SHIU CHOW, CHINA

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About 120 miles north of the city of Canton in the Province of Kwangtung is the city of Shiu Chow. It stands at the junction of two considerable streams which come down from the mountain borders of the Province and unite to form the Pei Kiang. The place can be reached by rail from Canton, and when the line is completed from Chu Chow to Shiu Chow, one can also reach it from Hankow by way of Changsha.

The rocks of the region are very deeply weathered limestones, sandstones, and shales of Middle Paleozoic age. The strata have been elevated in rather closely pressed folds whose trend is about $N10^{\circ}E-S10^{\circ}W$, and the dips range around 80° . No igneous rocks are known in the vicinity, although careful inquiry was made of the young man in charge of the mines, who has been college trained in Tientsin. In fact, a careful watch for igneous rocks for many miles along the railroad and over the hills failed to disclose a single outcrop.

In this part of China all travel, except by the railroad and the stream, is on foot over dirt roads or roads made of single stones laid along the path. Some of the foot-men carry chairs in which an occasional passenger could ride, but no wheeled vehicles are used at all, and scarcely any beast of burden. The ore from the mines is carried out some five or six miles on the backs of common coolie carriers, most of whom were women when seen in the summer of 1921. About two hundred carriers were engaged in transportation. Most of them make three trips per day, some only two. A strong man will carry about 130 pounds to a load; some are content with 80 to 100 pounds, and they receive the munificent sum of 25 cents a picul, which is equivalent to about 140 pounds. Thus these hard workers obtain from about 45 to 75 cents per day Chinese, and walk twenty to thirty miles, loaded one way.

The common mineral of antimony found in this locality is stibnite. It occurs in beautiful splendid crystals of characteristic color, and ranging in size from needles up to an inch through. A few of the prisms are striated parallel to the c -axis, but in most cases are parallel to b , and very regular and beautiful. Some of the prisms are curved; a very few seem to be capped with pyramids. Often a radiate arrangement is observed, but the commonest ar-

rangement is a criss-cross of prisms filling more than half the space. Calcite as gangue completes the vein.

The vein in which the ore occurs has a known width of about 4 feet; in some parts it is massive, with practically nothing foreign between the crystals of stibnite. In other places the stibnite is scattered through coarsely crystalline white calcite. This association with calcite seems to be a rather unusual occurrence for stibnite, quartz being the usual gangue. But in this Shiu Chow occurrence no quartz at all was found with the stibnite. On exposure the stibnite usually tarnishes to an iridescent blue, but some parts remain nearly black, and others stay gray. A careful search has revealed no pyrite at all in the vein.



FIGURE I

Left, calcite-veined limestone; right, stibiconite; small pieces, calcite and stibnite; center large piece, stibnite.

The country rock is a dark blue to dark gray massive limestone, containing many white calcite veins, some of which are an inch or two in thickness. The small veins are scarcely traceable without a lens. In this limestone near the veins, pyrite in very small crystals is of frequent occurrence and small quantities of stibnite also are found. Where the stibnite is found in the limestone it is worked until the percentage falls below 5%. The stibnite in the limestone is not well crystallized; in fact, often resembles a black sheet of slickensided clay. There is very little iron in these deposits except the pyrite.

Toward the surface the ore is weathered by oxidation and hydra-

tion to a yellowish gray or white heavy rock which runs 50% to 55% antimony. No anhydrous minerals were found, such as cervantite, valentinite, and senarmontite, but stibiconite is common. It is usually massive and varies in color from a lemon yellow through orange to white. It is rarely crystalline enough so that crystal forms can be identified, but small crystals can be seen with the lens. Several percent of milky quartz occurs with the ore in this weathered zone.

A number of shallow shafts have been opened in search for the ore, but none of these found anything beside float. A horizontal tunnel has been run straight back into the mountain, and this has encountered the four-foot vein mentioned above. The shaft and finds in the stream bed, together with the collection of float all along the hillside up to the line of the vein, make it clear that the deposit has considerable north and south extent.

About 12 or 13 miles south and southwest from these deposits, float ore is also found and brought to Shiu Chow to the smelter. This second deposit is along the strike of the rocks and suggests that the vein may be successfully traced the entire distance, for the ore is found between limestone and a shale, both of which occur at the second locality. Again about 33 miles north by northwest from Shiu Chow are small native workings for antimony in float and in the stream bed. Very pure stibnite from this locality is also brought to Shiu Chow.

All the work in this entire region is carried on by the simple laborious native methods. Ore and waste rock are removed in baskets on carrying poles or carried in the hands. Hoisting is done with a hand windlass. In the horizontal tunnel, small baskets are used. Tools are of the crudest sort, little hand drills and hammers, and occasionally a little blasting are all that are ever used for breaking up the rock. Fortunately the ore is not far up the mountain-side, but can be easily reached over the stony, tortuous foot-paths, and without any severe climbing.

This deposit seems to be peculiar in what it does not contain, for the gangue is almost free from quartz. No copper or lead or zinc is known with the stibnite, and the only weathered product found is the hydrous oxide, stibiconite. Mineralogists will be interested in following the development of this deposit, because of these differences from the ordinary antimony ores, and as the work proceeds, something else may be discovered. At present it is essentially a stibnite-calcite vein in massive Paleozoic limestone, produced without igneous activity.

NOTE ON THE CYPRINE FROM FRANKLIN FURNACE,
NEW JERSEY¹EARL V. SHANNON, *U. S. National Museum*

Specimens of a beautiful blue mineral recently found for the first time at Franklin Furnace have, within the past year, been widely circulated in mineral collections as cyprine. Specimens of this blue vesuvianite have been received at this laboratory, but when examined were found to be made up of such intimate mixtures of several minerals that it was almost impossible to distinguish the blue mineral from those intergrown with it, and quite impossible to secure a homogeneous sample for analysis. Some doubt was entertained as to the correctness of the identification of the material. In order to settle this question Mr. R. B. Gage recently sent a very fine specimen of this blue mineral from the Roebling collection to the Museum, with the permission of Col. Roebling to remove what was necessary of the material for an analysis. The results of the examination substantiate beyond a doubt the correctness of the original identification of this mineral as the blue cupriferous variety of vesuvianite, which has been given the varietal name cyprine. Since this is the first American occurrence of this variety and no complete description of the New Jersey material seems to be available, the results of the examination are set forth in some detail.

The specimen, which weighs approximately 350 grams (12 oz.), consists of approximately 80% of the cyprine and 20% of massive resinous brown garnet (polyadelphite) and nearly white bustamite. The cyprine forms radial, columnar aggregates of closely packed prisms which reach a maximum length of 2 cm. In color it is chiefly a beautiful azure blue although it varies abruptly to green in places. A sample of pure material, separated from the associated minerals with heavy solutions and proven homogeneous by optical examination, was analyzed with the results given in column 1 below, while in column 2 is given, for comparison, Lindstrom's analysis of the original cyprine from Tellemarken, Norway.

The composition of the Franklin material does not differ in any important respect from that of the Norwegian occurrence, nor from the average of available analyses of vesuvianite. While the constitution of the mineral need not be discussed here, it may be noted

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ANALYSES OF CYPRINE

	1	2
	FRANKLIN	TELLEMARKEN
SiO ₂	34.98	37.90
TiO ₂	—	0.26
Al ₂ O ₃	16.30	19.47
Fe ₂ O ₃	3.00	0.40
B ₂ O ₃	0.89	—
FeO	—	0.21
MnO	3.11	0.91
CaO	34.70	36.06
MgO	1.38	2.17
ZnO	1.42	—
CuO	1.21	0.73
Na ₂ O	—	0.14
K ₂ O	—	0.11
H ₂ O	0.64	0.67
F	1.62	1.72
Total	99.25	100.75

that the above analysis yields very nearly the simple formula, $4R''O \cdot R'''_2O_3 \cdot 3SiO_2$, with O in part replaced by $(OH)_2$ and F_2 . The value given for fluorine was not determined directly but represents the difference between total loss upon ignition and the water found by direct determination. Boric acid was determined directly on two portions using the method of Wherry and Chapin. The states of oxidation of the iron and manganese were not definitely determined although these are stated above as ferric and manganous, respectively.

Heated in platinum the powdered mineral turns first green and, at a higher temperature, black and at a bright red it fuses quietly to a clear black glass. In the forceps the mineral yields a mixed flame in which the red of calcium predominates, with streaks of green which is doubtless due to copper rather than boric acid as they become blue when the fragment is moistened with hydrochloric acid. In the closed tube at a high temperature the mineral yields strongly acid water and the tube is conspicuously etched by the fluorine. The hydrochloric acid solution, obtained by dissolving a sodium carbonate fusion of the mineral, reacts faintly for boric acid with turmeric paper.

Under the microscope the mineral is transparent and crystalline. The optical properties as determined by Dr. E. S. Larsen are: uniaxial, negative; indices of refraction $\epsilon = 1.698$, $\omega = 1.710$;

Pleochroic, ϵ =colorless, ω =pale blue-green. It thus differs from the average vesuvianite only in slightly higher birefringence.

The writer wishes to acknowledge his indebtedness to Col. Roebeling, Mr. Gage, and Ward's Natural Science Establishment for the privilege of examining specimens and to Dr. Larsen for the optical determinations.

POLARIZATION PHENOMENA OF CERTAIN FLUORITES

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While determining the refractive index of fluorite by the method of minimum deviation the writer introduced a nicol prism before the telescope of the goniometer to determine the plane of polarization of the refracted ray. On rotating the nicol no difference in the intensity of light could be observed, but on examining the reflected ray nearly complete polarization was obtained so that it was thought that the prism was not cut at the angle that should give polarization if Brewster's law applies to isometric crystals. A new prism was then cut from a crystal of fluorite from Madoc, Ontario, so that the angle between the reflected ray and the refracted ray should be ninety degrees. With this new prism the same phenomena were observed. A second nicol was now introduced between the collimator and the crystal so that the signal was extinguished. On rotating the two nicols simultaneously extinction was obtained throughout a complete rotation so that it would appear as though we may accept without question the statement that a ray of light passing through fluorite vibrates with equal facility in all directions at right angles to the direction of propagation and is not polarized.

On examining a standard glass prism for comparative purposes the refracted ray was found to be polarized in a plane at right angles to the plane of polarization of the reflected ray, indicating a marked difference in optical character between an amorphous substance and a cubic crystal, both of which give a single signal by the method of minimum deviation and are isotropic under the microscope.

To account for this behaviour of fluorite two hypotheses have occurred to the writer:

(1) Fluorite is singly refracting. The objection to this hypothesis appears in the polarization of the reflected ray with the absence of polarization in the refracted ray, for it is at once evident that if a

large portion of the light is polarized by reflection the residue must be more or less completely polarized by refraction, if we are dealing with a singly refracting substance.

(2) Fluorite is doubly refracting with $\alpha = \beta = \gamma$. A single signal would be observed in the refractometer and with one nicol the signal would be always bright while with crossed nicols extinction would occur with complete rotation of the nicols inasmuch as the phasal difference of the two rays equals 0λ .¹

In view of the writer's observations it seems to him that the difference in polarization phenomena of fluorite and glass can best be explained by including fluorite with the doubly refracting substances with $\alpha = \beta = \gamma$.

NOTES AND NEWS

A CENTURY OLD MINERALOGY. It is pleasing to discover an old book, especially so if it is on science and much more so if on the science of Mineralogy. Old mineralogies have long been relegated to the class of Wedgewood china; this particular one is entitled "INTRODUCTION TO MINERALOGY" and is a first edition copy printed in London, 1819. The author, ROBERT BAKEWELL, needs no introduction to American geologists as his "INTRODUCTION TO GEOLOGY" edited in this country by Professor Silliman of Yale reached its third edition by 1839. In view of the fact that its companion, the mineralogy, is unlisted in Dana's System, it seemed fitting to mention this book partly on account of its rarity on college shelves, but chiefly because the book itself, aside from its rarity, is deserving of notice for the happy, philosophical, and vigorous style in which it is written.

Professor Silliman adequately describes Bakewell as a geologist and writer in the following words that prefaced the third American edition of the geology by Bakewell.

"The author is distinguished by great independence of spirit, which carries him straight to his object, without any servile regard to previous systems. His theoretical views appear to be generally philosophical and just, and some of them are peculiarly happy."

Bakewell's Mineralogy consists of 668 pages and five large wood cut plates of crystal drawings. The five separate books making up the Mineralogy have the following headings: "Theoretical Mineralogy"; "Essential Characters of Earthy Minerals"; "Natural History and Character of Metallic Minerals"; "Combustible Minerals"; "Saline Minerals."

The book holds additional interest as the author was a contemporary of Haüy, Romé d'Isle, Werner, Kirwan, and Jameson; and in the preface Bakewell describes their methods and theories.

In speaking of Kirwan:

"So little attention was paid to mineralogy as a science in this country, that Mr. Kirwan's 'Elements,' published in 1784 and 1795, was the first regular treatise on the subject in our language entitled to notice."

¹ Iddings, Rock Minerals, p. 139.

He continues:

"On the continent of Europe, there are at present two schools of mineralogy, the German and the French; the founder of the former was the late distinguished professor at Freiberg, Mr. Werner, whose method of instruction has been followed in this country by Mr. Jameson, and fully and ably developed in his 'System of Mineralogy.'"

Of Werner he says:

"The peculiar merit claimed for Werner by his disciples is the invention of a technical language, to convey a correct idea of the external characters and appearances of minerals, such as the color, lustre, form, fracture, etc.; and in the description of minerals, according to the Wernerian method, all the external characters, whether essential or accidental, are most minutely detailed."

"In the system of Haüy, the crystalline structure and chemical composition of minerals are chiefly regarded, and only the most important external characters are noticed."

"Before the time of Werner, it is said mineralogists of different countries had no definite terms by which their description of minerals could be made intelligible to each other; but it may fairly be doubted whether the vagueness complained of in the descriptive language of former mineralogists did not proceed rather from defective or inaccurate observations, than from defective terms. Werner certainly introduced a greater degree of accuracy, in the examination of minerals; this is merit of a higher kind than the invention of new terms, many of which are harsh and obscure. In the German method of describing minerals, the meaning is sometimes almost buried under a heap of terms, which to speak in the language of that school, are 'particularly difficultly intelligible'; added to this, a mineral is often divided into so many species, subspecies, varieties, and kinds, according to the varieties of color, or other accidental qualities, that the learner finds the subject rendered obscure, by the multiplicity and minuteness of the illustrations. The descriptions may be compared to a window in a Gothic cathedral, where so much care has been taken to make the glass-work firm, by compartments and subdivisions of lead and stone, that the use of the window for the admission of light seems to have been forgotten."

Speaking of argentiferous galena, he says:

"Can we say that the lead was forming into silver, but was arrested in its progress, or is the change now taking place? I do not believe it unphilosophical to believe that the vivifying influence of creative energy descends to the deepest recesses of the earth, acting according to laws as regular as those which govern the motion of the planets in the heavens."

Among the various features in the book, Bakewell presents a table based on differences of specific gravity and hardness for the physical determination of (Earthy Minerals.) To justify this use of a physical table of minerals, he says,

"Chemistry and crystallography must form the basis of scientific mineralogy; but for practical use an arrangement according to the physical characters is required, in order to discover to what species any mineral possessing certain of these characters belongs; hence it appears that we should have two systems, one artificial, and the other scientific; the first, to enable us to refer a mineral to any known species, and to ascertain its name; the second, to enable us to class minerals according to their composition and structure, and to refer them to their true situation in the system of natural bodies."

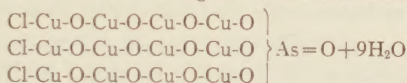
The far reaching and important effect of a well written book is shown in the case of Sir Charles Lyell who attributes his first attraction to Geology to the reading of Bakewell's Geology in his father's library. Charles Darwin in turn names Lyell as the man who first interested him in Natural Science. Bakewell's "Introduction to Mineralogy" equals his "Introduction to Geology."

It is apparent that this type of book on Introductory Mineralogy is the exception in the current science. Mineralogy of all earth sciences has need of able exponents for it is usually clothed in a technical language so mysterious to the average man. Bakewell made a strong plea for mineralogy, when he said:

"The acquisition of a new science is like the acquisition of a new sense; it enlarges the sphere of our intellectual power, presents Nature under a new aspect, and multiplies the objects of rational enjoyment."

T. L. GLEDHILL.

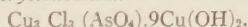
NOTE ON THE CONSTITUTION OF CERULEOFIBRITE. The remarkable mineral ceruleofibrite, described by Edw. F. Holden in the May issue of this journal (pp. 80-3) would have according to the structuralists some such formula as:



The fact that the water is given off at a high temperature is not opposed to this view; for in copper compounds water of constitution may be lost far below 100° (e.g. $\text{Cu}(\text{OH})_2$), while water of crystallization may require a red heat to drive it out (e.g. $\text{CuSO}_4 \cdot \text{H}_2\text{O}$). However, X-ray study of crystals has failed to demonstrate the reality of such structural formulas.

According to the coordinatists, it might be $(\text{OH})_3[\text{Cu}_{12}] \text{Cl}_3 \text{AsO}_4$ or $\text{Cu}_{12}[\text{AsO}_4] \text{Cl}_3(\text{OH})_9$, etc. The choice is extensive and the possibility of still further complicating its formula by multiplying thru by some factor is unlimited. But such arrangements do not tell much about the nature of compounds, nor are they confirmed by X-ray study better than the preceding type.

The simplest way of interpreting the mineral would appear to be as a tri-copper-tri chlor- arsenate with nine molecules of copper oxide plus water, or of *copper hydroxide of crystallization*:



E. T. W.

As a result of the publication of Professor A. L. Parsons' article on "The preservation of mineral specimens," in the April issue of THE AMERICAN MINERALOGIST, further suggestions have been received from Mr. P. Walther of the Newark Mineralogical Society, who for a number of years was connected with the Natural History Museum at Newcastle-upon-Tyne. To the list of minerals altered by exposure to light three additions may be noted, cinnabarite, chrysoprase and green fluorite. It is suggested that minerals sensitive to light be kept in cases provided with black covers, which can be easily removed when specimens are inspected. It was also observed that copper and iron sulfates when dipped in alcohol and then permitted to dry in a place free from direct sunlight, remained clear for several years. The disintegration of specimens of fossil fish was also arrested by cleaning thoroughly with alcohol and then immersing in a solution of ozokerite and benzene.

Professor P. v. Groth will celebrate his 80th birthday on June 23, 1923. In recognition of his work as investigator, author and editor, the present editor of the

Zeitschrift für Kristallographie, Dr. P. Niggli, is planning a special number (Vol. 58 or 59) of the Zeitschrift in honor of this eminent mineralogist. Manuscripts for this volume which should not exceed three pages in length, should be in the possession of Dr. Niggli, Mineralog.-petrogr. Institut der Eidg. Techn. Hochschule, Zürich, Sonneggstrasse 5, by December 31st, 1922. Also contributions towards defraying the cost of the volume will be gratefully received.

Friends and former students of Professor Victor Goldschmidt are planning a memorial to be presented on his 70th birthday which falls on the 10th of February, 1923. This memorial will also commemorate Dr. Goldschmidt's 35th year as teacher at the University of Heidelberg. Those wishing to participate in honoring this noted crystallographer are asked to send their name and contribution to Dr. Oscar Neff, Karlsruhe, Kriegsstr. 85.

PROCEEDINGS OF SOCIETIES

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences of Philadelphia, June 8, 1922

A stated meeting of the Philadelphia Mineralogical Society was held on the above date with the president, Mr. Trudell, in the chair. Nineteen members were present.

Mr. John Frankenfield addressed the society on "A MINERALOGICAL TRIP TO VIRGINIA." The localities at Amelia, Natural Bridge, Midvale, Irish Creek, and Luray, were described, and illustrated with many beautiful lantern slides. Specimens of albite, beryl, scorodite, dufenite, and strengite were exhibited.

Trips to Vanartsdalen's quarry, Jones mine, and quarries in Germantown and Frankford were reported by Messrs. Knabe, Biernbaum, and Oldach.

The president described the following excursions of the society: on May 21st, to the American Museum of Natural History in New York to see the new installation of the Clarence Bement collection of minerals; and on June 4th, to Dover, N. J., to see the magnificent collection of Mr. Frederick Canfield. The serpentine locality at Hoboken was also visited, specimens of brucite, magnesite, and hydromagnesite being obtained. Lantern slides were exhibited of pictures taken on the two occasions.

The secretary announced that Mr. Charles K. Shaw of Chester, Pa. had presented to the Academy the mineral collection of his father, William H. Shaw (1855-1900). The collection is extremely rich in Delaware County amethysts, beryls, garnets, etc., although by no means limited to local minerals. Of exceptional interest are three large amethysts from the Shaw and Esrey quarry, two of which are over a foot in length; and a suite of amethysts from the Morgan Station locality. A selected series of specimens was exhibited. SAMUEL G. GORDON, *Secretary*.

BOOK REVIEW

ESSENTIALS FOR THE MICROSCOPICAL DETERMINATION OF ROCK-FORMING MINERALS AND ROCKS. ALBERT JOHANNSEN. 53 pages, 8vo, 24 figures, 4 tables. The University of Chicago Press, Chicago, 1922.

This book is designed primarily as a *laboratory manual* for students of petrography and should be used in conjunction with the writer's *Manual of Petrographic*

Methods, or some other text of a similar character. The laboratory manual contains much of the material originally published in the author's *Determination of Rock-Forming Minerals*, but the scope of this work has been somewhat enlarged by including modes of occurrence, distinguishing characters of similar minerals, and a survey of a quantitative mineralogical classification of igneous rocks.

The main optical constants of the rock-forming minerals are very conveniently condensed into six one page charts. This has been made possible by grouping the minerals having birefringences greater or less than quartz, and refractive indices greater or less than Canada balsam (1.537); thus avoiding needless repetition and saving the student considerable time.

The portion devoted to the determination of the feldspars is both helpful and suggestive. Thirteen methods (one physical and twelve optical) are discussed for determining the various members of the plagioclases, and in many instances the results obtained are plotted graphically. The separation lines between the various plagioclases are now given at 5, 27½, 50, 72½, and 95 per cent anorthite. Albite and anorthite have been limited to a variation of only 5 per cent since these names are also applied to the pure end members. Compound names such as oligoclase-albite, labradorite-bytownite, etc., have been dropped.

The portion dealing with a summary of the optical methods used in determining minerals hardly seems adequate, as the space thus devoted is limited to three pages and placed *after* the description of the minerals, instead of *before* where it logically belongs.

A very welcome contribution is the portion, consisting of 9 pages and 4 tables, relating to the writer's quantitative mineralogical classification of igneous rocks. Rules for the determination of rocks are likewise given, so that when the minerals and their percentages have been ascertained, the rock name also may be known.

Because of the convenient and condensed manner in which the material has been presented and the up-to-date treatment of the subject, especially from the quantitative view-point, this book should make a strong appeal to every student of petrography.

W. F. H.

NEW MINERALS: NEW SPECIES

FAMILY: SILICATES. DIVISION: R'' : R''' = 1:2.

Gillespite

WALDEMAR T. SCHALLER: Gillespite, a new mineral. *J. Wash. Acad. Sci.*, 12(1), 7-8, 1922.

NAME: After Frank *Gillespie* of Richardson, Alaska, its discoverer.

CHEMICAL PROPERTIES: *Formula*: $\text{FeO} \cdot \text{BaO} \cdot 4\text{SiO}_2$ or $\text{FeBaSi}_4\text{O}_{10}$. Not closely related to any well-marked mineral group. Before the blowpipe it fuses easily to non-magnetic globule; in closed tube darkens but regains original color on cooling. Readily decomposed by HCl with the separation of flakes of silica, which are doubly refracting; also decomposed by H_2SO_4 . A hand-picked sample gave, SiO_2 50.08, FeO 14.60, BaO 31.02, Al_2O_3 0.34, Fe_2O_3 0.56, " Mn_2O_3 " 0.14, insol. 2.20, H_2O (non-essential) 0.82, sum 99.76%. Ratios very close to 4:1:1 for first 3 oxides.

CRYSTALLOGRAPHIC AND OPTICAL PROPERTIES: System either tetragonal or hexagonal, only basal planes being definitely recognizable. Uniaxial negative with very low birefringence; strongly pleochroic. Refractive indices: ϵ (rose-red) 1.619, ω (pale pink) 1.621.

MISCELLANEOUS PHYSICAL AND MECHANICAL PROPERTIES: Color red (Ridgway XII 71 i to XXVI 71 b); streak pink; luster vitreous; translucent. The color is suggested to be due to manganic manganese, supplementing ferric iron. Brittle, with well developed basal cleavage; $H = 4$; sp. gr. ≈ 3.33 .

OCCURRENCE: Represented by a small rock specimen found in a moraine near the head of Dry Delta, Alaska range, Alaska. Admixed with diopside and barium-feldspar, and probably of contact-metamorphic origin.

DISCUSSION: The abstractor does not consider it probable that any manganese could occur in the manganic state in the presence of excess ferric iron, and would prefer to class this among minerals the cause of whose color is as yet undetermined.

E. T. W.

REDEFINITION OF SPECIES

FAMILY: SILICATES. MINERALOID DIVISION: R'' : R''' : $H_2O = 1:1:X$.

Neotocite

N. NORDENSKIOELD, 1852 (Including "stratopeite" and perhaps other "minerals"). Redefined by PARDEE, LARSEN, AND STEIGER, *J. Wash. Acad. Sci.*, **11**, (2), 31, 1921.

CHEMICAL PROPERTIES: *Formula*: Variable because of colloidal nature but roughly $MnO: SiO_2: XH_2O$ or $MnSiO_3 + XH_2O$. Percentage of MnO (with some replacement) approximately $7/6$ that of SiO_2 ; water (adsorbed) usually 14-17%, escaping more or less continuously as temperature is increased from 50° .

A new analysis by Steiger on material associated with the Washington bementite agrees essentially with the five earlier ones on material from various localities in Sweden, Finland and Germany. Difficultly fusible. Decomposed readily by HCl with separation of sandy silica.

CRYSTALLOGRAPHIC AND OPTICAL PROPERTIES: Amorphous, tending to become cryptocrystalline (metacoloidal). Under the microscope brown, isotropic, with n ranging from 1.45 to 1.56; the metacolloid approaches bementite in optical properties.

PHYSICAL PROPERTIES: Color black. Streak brown. Resembling a black glass in aspect and in conchoidal fracture. H . 3-4; sp. gr. averaging 2.8.

OCCURRENCE: An alteration product of various manganese silicates.

DISCUSSION: It is recommended that the name neotocite should be definitely limited to amorphous (colloidal) manganese silicates with ratio approximating 1:1.

E. T. W.